NASA TECH BRIEF

Aerodynamic Forces of Fluttering Cylindrical and/or Planar Structures

In recent years much attention has been devoted to panel flutter instability, both theoretically and experimentally. The complexity of the phenomena has resulted in the necessity of developing separate design criteria for a variety of flow conditions and panel configurations. Vehicle panel configurations with very low aspect ratios are of specific interest in the region of low supersonic flow, where boundary layer effects are important.

In previous analyses of panel flutter, methods were developed to obtain approximate solutions of the complete problem and exact solutions of various approximations of the problem. In the first instance the Galerkin or assumed mode approach has become more or less standard. On the other hand, the two approximations of the problem that have been given the most serious attention are those based on static aerodynamic theory and quasi-steady theory. The approximations based on static and quasi-steady theory have served an important role in providing basic understanding of panel flutter phenomena, and indeed, each theory has a significant domain of quantitative validity; namely, for low-frequency and high supersonic Mach number. Unfortunately, both approximations fail in the low supersonic regime which has been shown to be a critical region for panel flutter. In this region the exact aerodynamic forces must be retained in the formulation of the problem.

The Galerkin method is a very powerful tool for solving the exact problem when the length-to-width ratio of the panel is of order unity or smaller. For such geometry the flutter mode shape can be approximated closely with only a few (usually two) natural vibration modes so that the resulting flutter matrix is of tractable size. However, when the length-to-width ratio becomes large the number of half waves in the chordwise flutter mode becomes large and also the mode shape has a strong exponential growth in the chordwise direction with larger deflection near the trailing edge. To resolve this type of flutter mode into Fourier components, one must use a large number of vacuum normal modes and consequently must be able to handle a very large flutter matrix to obtain convergence. The result is that the computational effort required to obtain a single flutter point grows out of proportion to the magnitude of the problem.

A new method for solving an exact formulation of the problem was introduced; the problem treated was that of an infinite spanwise array of identical panels. Exact aerodynamic theory was employed to solve the problem by Laplace transforms. The difficulties associated with the Galerkin method were circumvented in that the mode shape and its derivatives were obtained quite naturally in the process of solution. The present work includes membrane stresses and the alternative of pinned or clamped leading and trailing edges. The pinned edge case has been developed to a point where numerical calculations can be performed.

Note:

The following documentation may be obtained from:

Clearinghouse for Federal Scientific
and Technical Information
Springfield, Virginia 22151
Single document price $3.00
(or microfiche $0.65)

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(continued overleaf)

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